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GUELPH

Grain Smuts

By

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INTRODUCTION

The objects of this bulletin are to make available to the farmers of Ontario the knowledge scientific workers have acquired concerning the nature of grain smuts and to give them concise information about the best methods of preventing grain smuts.

With these objects in view, the writers have endeavoured to discuss the subject in clear, simple, non-technical language, so that all who read this bulletin may readily understand it. It is hoped that this bulletin may help to spread more widely the information which will aid farmers in preventing losses from smuts.

The methods of preventing grain smuts recommended in this bulletin are those which experiments extending over a period of ten years have proved to be safe and effective. They cost but little and are easily and quickly applied.

LOSSES DUE TO GRAIN SMUTS

It is extremely difficult, if not impossible, to estimate the financial loss caused by these diseases. The following rough estimate of the loss has been made by considering the value of the different grain crops grown in Ontario each year and the estimated annual average per cent. that the yield of the different crops is reduced by smut.

Oats.

Market value of the yearly crop about.....$50,000,000
Estimated annual loss due to oat smut 5 per cent..... $2,500,000

Wheat

Market value of the yearly crop about.....$26,000,000
Estimated average annual loss due to smuts 5 per cent..... $1,300,000

Barley

Market value of the yearly crop about.....$17,000,000
Estimated annual loss due to smuts 4 per cent. of crop..... $680,000

CORN (GROWN FOR HUSKING)

Market value of the yearly crop about	$7,000,000
Estimated average annual loss to corn 2 per cent	$140,000
Total yearly financial loss	$4,620,000

These figures are but approximate, but they serve to impress the fact that the annual loss caused by grain smuts is very much larger than is generally realized. This financial loss to farmers in Ontario is to a large extent a needless one, as nearly all grain smuts can be prevented almost entirely by proper treatment of the seed.

THE CAUSE OF GRAIN SMUTS

The grain smuts are fungus diseases, that is, they are caused by minute, colourless plants called fungi which have lost the power of manufacturing their own food and have become thieves or parasites stealing their foods from other plants and in so doing injure them in various ways, thus causing what are known

FIG. 1.—Smut of oats.
(About one-half natural size.)

FIG. 2.—Stinking smut of wheat on left and loose smut of wheat on right.
(About one-half natural size.)

as fungus diseases. The bodies of the fungi which cause smuts of grain consist of fine, delicate threads or tubes (hyphae) which are so exceedingly small that they can be seen only with the aid of a microscope. These hyphae or threads live between the cells of the grain plant and obtain their nourishment from them. Some of these fungus threads (hyphae) become changed into reproductive structures termed spores which serve the same purpose as the seeds of flowering plants, viz., dispersal and reproduction.

The spores of smut-producing fungi usually form in the ears or heads of the grain. The fungus threads (mycelium) attack the flowers when they begin to develop and feed upon the food being stored in the forming seeds. When this is exhausted they develop into millions of little spores. These compose the black smut masses so familiar to every farmer. These spores are exceedingly small. Some idea of their size may be had by considering the fact that each smutted wheat grain contains from two to three million spores.

The spores of smut fungi are scattered by the wind or by the threshing or handling of the grain in the case of some of the smuts. Each spore, if placed under proper conditions, is capable of reproducing its kind, finally causing again that particular smut peculiar to the parent fungus.

OAT SMUTS

Loose Smut of Oats is the commonest and most troublesome grain smut in Ontario.

Symptoms.—Loose Smut is noticed in the fields just as soon as the oats begin to head. It destroys the kernels, hull and chaff, changing them to a dark brown powder resembling soot, so that the whole head becomes a mass of smut. This smut mass is composed of millions of spores which are frequently blown away by the wind, leaving only the naked branches of the inflorescence (Fig. 1).

Cause.—Loose Smut is caused by the fungus *Ustilago avenae* (Pers.) Jensen. Until very recently it was thought that this fungus was carried over as spores on the kernel of the oat inside the hull. *Recent investigations indicate, however, that this fungus is carried over as the dormant fungus threads (mycelium) in the outer coat (pericarp) of the kernel. From a practical standpoint the important point in the life history of this organism is that it is carried over near the surface of the kernel where it can be reached and destroyed by a seed disinfectant.

Covered Smut of Oats caused by the fungus *Ustilago laevis* (K. & S.) Mag., is also present in Ontario, but in so much as the treatment for the two smuts is the same from the standpoint of a practical man they may be considered as one disease.

Prevention.—Oat smuts can be prevented by the formalin spray and the formalin sprinkle methods described on pages 11, 12 and 13 of the bulletin.

N.B.—No formalin treatment can be used safely with hulless oats. Smut in hulless oats can be prevented without injury to the germination of the seed by treating with copper carbonate dust.

WHEAT SMUTS

There are two common smuts of wheat in Ontario—Stinking smut or Bunt and Loose smut. It is very important that farmers should learn to distinguish between these two kinds, as stinking smut or bunt can be prevented by treating the seed with copper carbonate dust or formalin, while such treatment is of no use whatever in preventing loose smut. A little study will enable even a casual observer to distinguish between these two diseases.

Stinking Smut or Bunt

This is the more objectionable smut of wheat. A very small quantity of this smut renders wheat unfit for milling purposes. In some years it is far too prevalent in Ontario. This is owing to the fact that too many farmers fail to treat their seed.

*Gage, G. R. Cornell Univ. Agr. Exp. Sta. Mem. 109.

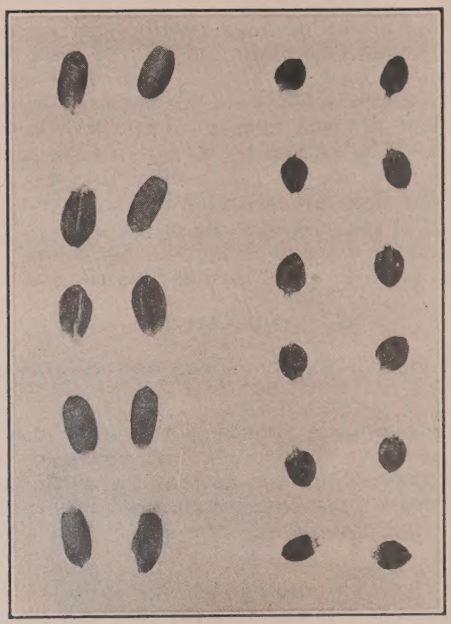

FIG. 3.—Sound grains on left; bunted grains on right. (About one-half natural size.)

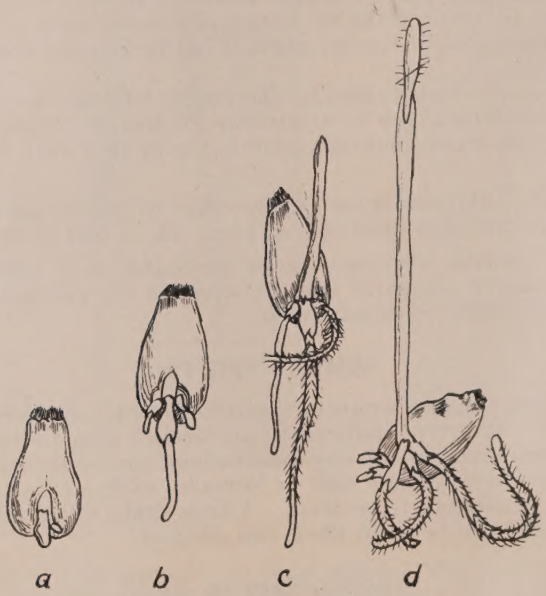

FIG. 4.—Germinating wheat grain showing stages in which infection may take place. *a*, *b*, *c*—Infection may occur only in these stages. *d*—No longer subject to infection. (Drawings adapted from diagrams, "The Life of the Wheat Plant," issued by the Royal Agricultural Society of England, prepared by Francis Bauer under supervision of Dr. Wm. Carruthers, F. R. S.).

SYMPTOMS.—This smut cannot be detected in the fields until the ears begin to fill. The smutted ears are darker green and remain green longer than the healthy ones. Later the affected ears usually stand up stiff and erect and the chaff is somewhat bleached and more or less distended (Fig. 2). The grains only are directly affected. They are short, plump, light in weight, somewhat discolored and filled with a brownish black, somewhat oily powder which has an odour like decaying fish. When a bunted grain "smut ball" is broken the disagreeable odour of the powder within is very pronounced (Fig. 3). These "smut balls" are broken and the powder scattered in threshing and handling the grain. Hence this smut even in small quantities can be detected by the odour it imparts to the wheat.

CAUSE.—Stinking smut or Bunt of wheat is caused by two closely related but distinct smut fungi—a smooth spored species, *Tilletia laevis*, Kühn, and a rough spored species, *Tilletia tritici* (Beij.). Wint. The life histories of these two fungi are practically the same. The dark, ill-smelling powder in the diseased grains consists of numerous spores. It has been estimated that one "smut ball" may contain between 2 and 3 million spores. The "smut balls" are broken during the threshing and handling of the wheat and the spores scattered among the sound grains, to which they adhere. The fungus is thus carried over as spores on the seed. When the seed is sown and germinates, the spores also germinate and produce delicate threads which enter the very young seedling plants. The infection of the wheat plant can take place apparently only during the short period from the beginning of germination to the time when the first green leaf pushes through the colourless sheath in which it is enclosed (See fig. 4). This is the only time that the fungus can gain entrance to the wheat plant. The fungus lives and grows inside the wheat plant following the growing point up the stem and when the ears begin to form enters the young ovaries and feeds on the starches, etc., being stored in them. The fungus threads which fill the diseased ovaries finally divide up into countless spores which form the dark-coloured powder which fills the bunted grains.

The temperature at seeding time has a marked influence on the amount of infection that takes place. Results of scientific investigation show that wheat is not infected at low temperatures, but as the temperature of the soil is raised the number of plants becoming affected increases until at a temperature of 41 to 50 degrees F. the maximum infection takes place. A further increase in temperature causes a decrease in the amount of infection until at 70 degrees F. wheat completely escapes attack.*

PREVENTION.—Stinking smut or Bunt can be prevented by treating the seed with copper carbonate dust or with formalin.

Our experiments have shown that copper carbonate dust controls Stinking smut of wheat without lessening germination and is at the same time quickly and easily applied. (See directions, pages 13, 14 and 15.)

Sprinkling with a formalin solution (1 pint to 40 gallons of water) has also been found effective, but in some seasons has reduced the germination of the seed to a noticeable extent. (See directions, pages 12 and 13.)

Seed wheat which is to be treated for smut should first be thoroughly cleaned. This can be done with a good fanning mill. The cleaning of the wheat is especially important when formalin is used, for if the "smut balls" are not removed the formalin treatment will not be entirely effective.

LOOSE SMUT OF WHEAT

This smut is more common and does more damage to wheat in Ontario than is generally realized by the grain grower. This is owing to the fact that

*Based on Woodman, H. M., and H. B. Humphrey—U.S. Dept. of Agric. Bull. 1239—1924.

most of this smut is blown away long before harvest time and thus may be overlooked by the grower unless he happens to be inspecting his fields about the time the wheat is coming into ear.

SYMPTOMS.—Loose smut is seen in the field just as soon as the wheat begins to ear out. It destroys both the grains and the chaff, changing them to a black powder. The whole head thus becomes a black smut mass. These smut masses are broken up and blown away by the wind, the only remaining evidence at harvest time being the naked central axis of the ear (Fig. 5).

FIG. 5.—Loose smut of wheat. (About natural size.)

CAUSE.—This smut is caused by the fungus *Ustilago tritici* (Pers.) Rostr. The smut masses consist of millions of spores. These are scattered by the wind when the wheat is in flower. Some of these spores reach sound ears of wheat and get in between the chaff on to the flowers. The spores germinate at once and produce delicate fungus threads (germ tubes) which gain entrance to the developing grain. Once inside the grain the fungus remains dormant. The infected grains are perfectly sound and there is no way of telling them from the grains not infected except by skilful microscopic examination. The loose smut fungus is thus carried over from season to season as the dormant fungus threads (mycelium) in the seed (See fig. 6).

When the seed is sown and germinates, the fungus threads inside begin to grow and follow the growing point up the stem finally invade the ears and chaff and convert them into a mass of smut.

TREATMENT.—Loose smut of wheat CANNOT be prevented by treating the seed with copper carbonate dust or formalin. If possible, secure seed from a district where loose smut is not present. Such seed will produce a crop free from this smut. If this smut is very prevalent and it is impossible to secure seed from a district free from it, it may be necessary to establish a seed plot and treat the seed as directed by the hot-water treatment described on pages 16 and 17.

SUMMARIZED COMPARISON OF STINKING SMUT AND LOOSE SMUT

Loose Smut

1. Destroys both the grain and chaff.
2. Has no disagreeable odour.
3. Spores scattered by the wind at flowering time.
4. Fungus carried over as fungus threads (mycelium) inside the seed.
5. Cannot be prevented by treating the seed with copper carbonate dust or formalin.

Stinking Smut

1. Destroys only the grain.
2. Has a very disagreeable odour.
3. Spores scattered in threshing and handling of grain.
4. Fungus carried over as spores on seed.
5. Can be prevented by treating the seed with copper carbonate dust or formalin.

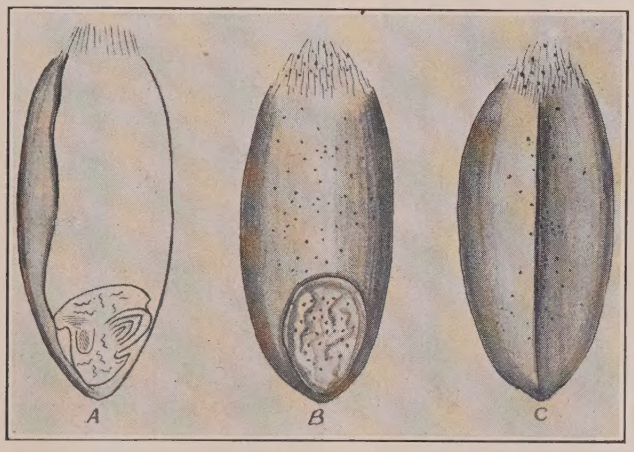

FIG. 6.—Difference in the method by which Loose smut of wheat and Stinking smut or Bunt is carried over from crop to crop.
A. Mycelium of the Loose smut fungus IN the wheat germ.
B. and C. Spores of Stinking smut or Bunt ON the wheat grain.

BARLEY SMUTS

There are two kinds of barley smut, viz., Loose or Naked Smut of Barley and Covered Smut of Barley. The former appears to be the more prevalent and more serious disease in Ontario. It is very important that farmers should learn to distinguish these two smuts, as the Covered Smut can be prevented by treating the seed with formalin, while such treatment cannot be relied upon to prevent Loose or Naked Smut.

LOOSE OR NAKED SMUT

This is the smut which does the most damage to barley in Ontario.

SYMPTOMS.—It is very similar in appearance to Loose Smut of Wheat. It is observed in the fields just as soon as the barley begins to ear out. It converts both the chaff and the grain into a black powder resembling soot. This powder, which is in reality a mass of spores, is soon blown away by the wind, so that at harvest time there is nothing left but the naked axis of the ear. (See fig. 7.)

CAUSE.—Loose Smut of Barley is caused by the fungus *Ustilago nuda* (Jens.) Kellerman and Swingle. The life history of this organism is very similar to that of the fungus which causes Loose Smut of Wheat. The spores are

FIG. 7.—Loose or naked smut of barley. (About one-half natural size.)

FIG. 8.—Covered smut of barley. (About natural size.)

scattered by the wind when the barley is in flower. Some of them reach healthy ears of barley and drift in between the chaff onto the flowers. They germinate at once and produce delicate fungus threads (germ tubes), which reach and penetrate the developing grains. Once established inside the grain, the fungus soon becomes dormant. Infected grains are perfectly sound and there is no way of telling them from grains which are not infected, except by very delicate and skilful microscopic examination. The fungus which causes Loose or Naked Smut of Barley is thus carried over mainly as dormant fungus threads (mycelium) inside the seed. On the germination of the seed the fungus threads commence to grow inside the germ and as the plant develops, follows the growing point up the stem, finally invading the flowers and chaff and converting them to a mass of smut.

*Recent investigations indicate that the fungus which causes this disease may in some varieties of barley live over at least in part as spores on the seed.

PREVENTION.—The Department of Botany, during the last few years, has experimented with a large number of seed disinfectants in the hope of finding a simple, easy treatment for the prevention of this smut. None of these proved reliable, and the hot-water treatment, as recommended for Loose smut of wheat, is the only one which has been found wholly effective, and it is, therefore, recommended for Loose smut of barley (See pages 16 and 17 for directions).

COVERED SMUT OF BARLEY

SYMPTOMS.—This smut attacks the chaff and kernels, but the smut mass usually remains covered, each smutted grain (spore ball) being enclosed in a delicate, white skin. This smut is often found in the threshed grain in the form of black, irregular masses. It is sometimes difficult to distinguish the Covered from the Loose smut of barley, but the former may be recognized usually by its later appearance in the field, by the white membrane covering the smut balls and the coal-black colour of the smut mass. (See fig. 8.)

CAUSE.—This smut is caused by the fungus *Ustilago hordei* (Pers.) Kellerman and Swingle. The spores of this fungus may be to some extent liberated and scattered by the wind before the grain is harvested, but probably most of them are dispersed in the threshing and handling of the grain. The fungus is carried over from season to season as spores adhering to the seed. This smut can get established in the barley plants only when they are in the very young seedling stage. The life history of the fungus causing covered smut of barley is, therefore, for all practical purposes, similar to that of the organism causing stinking smut of wheat.

PREVENTION.—This smut can be prevented by sprinkling the seed with formalin solution (1 pint to 40 gallons of water. See directions, pages 12 and 13).

SUMMARIZED COMPARISON OF LOOSE AND COVERED SMUT OF BARLEY

Loose	*Covered*
1. Appears earlier; begins to show as soon as the ears appear.	1. Does not show until about 2 weeks later.
2. Smut masses usually dispersed by the wind soon after they appear, leaving only the bare stalks.	2. Smut masses usually remain until harvest.
3. The smut mass has a dark brown colour. The skin around it very soon ruptures.	3. The smut mass is almost coal-black, and the white skin usually remains around it.
4. The fungus is carried over mostly as the fungus threads (mycelium) in the seed.	4. The fungus is carried over as the spores on the seed.
5. Formalin treatment cannot be relied upon to prevent this smut.	5. Formalin treatment will prevent this smut.

CORN SMUT

This smut is exceedingly common and is familiar to every farmer who grows any corn. The sugar or table corns seem to be more subject to smut than the field corns, but no commercial varieties are known that are entirely

*Tisdale, W. H., and B. F. Bapke—Journal Agric. Research-29: 263-284—1924.

free from smut. Many farmers consider the loss due to corn smut too small to demand any particular attention, but the aggregate loss in Ontario is undoubtedly large. In the corn-growing sections of the Province this smut causes an appreciable loss to the growers nearly every year.

SYMPTOMS.—Corn smut is not confined to the ears, but affects also the stalks, leaves and tassels. It produces on the parts attacked peculiar growths, usually spoken of as "boils." These "boils" are sometimes six or more inches in diameter. They are white and polished in the early stage, but become darker as they mature, and finally rupture and expose a brownish-black mass of powder consisting of millions of spores (Fig. 9).

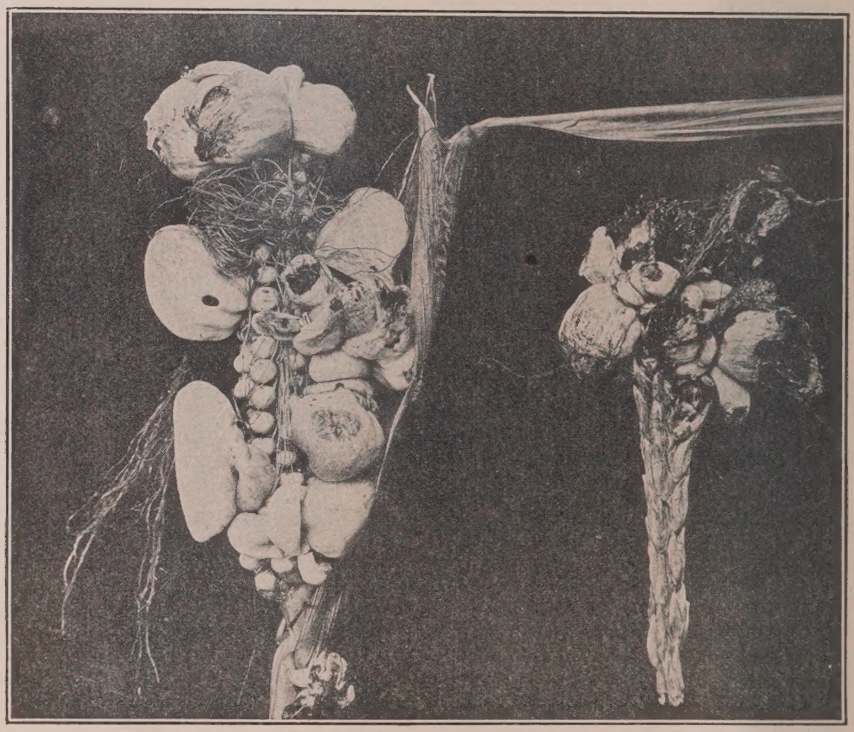

FIG. 9.—Corn smut on ear and tassel. (About one-half natural size.)

CAUSE.—This smut is caused by the fungus *Ustilago zeae* (Beckman) Unger. As soon as the "boils" mature and rupture, the spores are scattered by the wind and other agencies. These spores germinate in soil or in manure and produce great numbers of secondary spores, which may infect any of the tender growing tissues of the corn plants. Thus the smut is spread during the growing season. There may be several generations of corn smut in a season favourable for the development of the fungus which causes it. The fungus is carried over the winter as spores in the soil and in manure. These may be contaminated in various ways. The spores may be scattered by the wind or the spore masses may be left in the field or thrown on the refuse or manure pile. It is believed that the spores of this fungus not only live in the manure pile, but that they may actually grow and increase in number in warm, fermenting manure.

Prevention.—No seed treatment will prevent corn smut, as the fungus which causes it is carried over the winter as the spores in the soil and in manure. There is no way of entirely preventing corn smut. It can be much reduced, however, by the following precautions:—Avoid applying fresh manure directly to the corn crop, as it is very likely to contain live smut spores. If possible, practice a rotation of crops. The spores of this fungus will not live for many years in the soil, and those which are in the soil cannot injure any other farm crop. After three or four years, corn may be planted again with less danger, as many of the spores will have lost their vitality by this time. When only a small area of corn is grown, go over the field and cut out and burn all smutty growths as soon as they appear, as each "boil," when mature, is a source of infection to the healthy plants around it. Experiments carried out at the College have shown that when smutty corn is put in the silo most of the spores of the fungus are destoryed by the acids developed during the fermentation of the ensilage.

Methods of Preventing Grain Smuts

There are a number of successful methods of treating grain to prevent smut. Those which ten years' experiments conducted by the Department of Botany have proved to be the most effective and most simple in application will be described here.

Formalin Treatments

There are several simple and effective methods of treating seed grain with formalin. They are briefly described below. The grain should be sown as soon as possible after being treated with formalin.

Formalin Spray

This method has been tested for ten successive years by this Department. In all, some forty field trials under ordinary farm conditions have been made and over 3,200 bushels of oats treated by this method. The results have been uniformly satisfactory. In no instance has there been any appreciable injury to the grain, and the control of the smut has been almost perfect. In no case has there been more than a very small percentage of smut in any field in which treated seed was sown. While the smut in the fields sown with untreated seed for a check averaged 5.71 per cent., in some of the fields sown with untreated seed the amount of smut was as high as 15 per cent. This method is recommended for the prevention of oat smuts only in the ordinary or hulled varieties of oats. It is not recommended for hulless oats, as formalin prevents the proper germination of hulless varieties of oats.

Directions.—

Materials needed: Formalin (40 per cent. formaldehyde).
A quart sealer sprayer.
Water.
Sacks or blankets, tarpaulin, etc.
A clean floor on which to spread out the treated seed.
Shovels for mixing the grain.

Use equal quantities of formalin and water; that is, one pint of formalin to one pint of water. A quart of this solution should be applied to fifty bushels of oats. If smaller or larger quantities are treated be sure to use proportional amounts of the formalin solution. Thus 25 bushels of oats require only ½ pint of formalin mixed with ½ pint of water. A small quart sealer sprayer, like the

one shown in the accompanying illustration (Figure 10), is the most convenient for applying the formalin solution to the oats. A sprinkling can is not satisfactory.

Sweep a portion of the granary or barn floor, then spray it with a little of the formalin solution. Place the oats to be treated in a pile on the floor and shovel them into another pile on the sprayed portion of the floor, and as they are being shovelled over spray them with the formalin solution.

Two men can best do the work. One man should shovel the grain while the other sprays each shovelful (See figure 11). When finished, spray the bags on both the inside and the outside and cover the pile of oats with them. Old carpets, blankets, tarpaulin, etc., may be used to cover the treated oats, but should first be sprayed the same as the bags. Leave the oats covered for four or five hours, then uncover them and they are ready to sow (Figure 12). When treating the oats by this method, open the doors so as to give plenty of ventilation and hold the sprayer close to the oats. If this is not done, the strong

Fig. 10.—Quart sealer sprayer for the formalin spray method.

Fig. 11.—Applying the formalin spray.

Fig. 12.—Oats covered with sacks after applying the formalin spray.

fumes of formalin will cause much irritation to the eyes, nose and throat. The advantages of this method over those which have been practised here before are simplicity, rapidity and ease of application. In our experiments it was found that 100 bushels of oats could be treated in 50 minutes by this method. There was no waiting for the seed to dry after treatment, no danger of its sprouting or moulding or of the grain being swollen so that it would not run freely through the seed drill.

Formalin Sprinkle

This method is recommend for the prevention of Oat Smuts and Covered Smut of Barley. It can be used also for the prevention of Stinking Smut or Bunt of Wheat. It is, however, not as safe and satisfactory a treatment for this smut of wheat as is the copper carbonate dust treatment described elsewhere.

Materials needed: Formalin (40 per cent. formaldehyde).
A barrel.
Water.
Shovels for mixing the grain.
An ordinary garden sprinkling can.
A clean floor on which to spread out the treated seed.

DIRECTIONS.—Mix one pint of formalin with 40 gallons of water. Place the grain to be treated on a clean floor. Sprinkle the formalin solution over the grain, then shovel the grain into another pile, so as to mix it thoroughly, then sprinkle and shovel again. Repeat this operation until every grain is moistened by the solution. Just enough of the solution should be applied to thoroughly moisten every grain, but not enough to make the pile wet and soppy. Forty gallons of this formalin solution is sufficient to sprinkle between 50 and 60 bushels of grain, so that it takes ⅔ of a gallon or more per bushel. It is important to use proportional amounts of the formalin solution. After the grain has been thoroughly sprinkled, cover the pile with bags, sacks, blankets, etc., which have been sprinkled with or soaked in a formalin solution and leave for three or four hours. At the end of this time uncover the grain and spread it out thinly to dry. It is often advisable to shovel it over 3 or 4 times to hasten drying (See figures 13 and 14).

N.B.—No formalin treatment can be used safely with hulless oats. Smut in hulless oats can be prevented by treating the seed with copper carbonate dust (See directions below).

FIG. 13.—Sprinkling with a formalin solution.

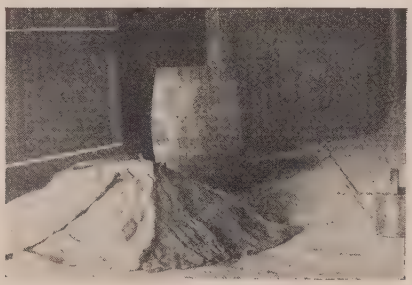

FIG. 14.—Grain covered with sacks after treatment.

COPPER CARBONATE DUST TREATMENT

This treatment is recommended for the prevention of Bunt or Stinking Smut of Wheat and smut in hulless oats. It will not control smut in grain with a hull such as ordinary oats or barley. This treatment will not prevent Loose smut of wheat.

Materials needed: Copper carbonate dust.
Dust mixing machine.
A shovel for handling the grain.

DIRECTIONS.—This dust should be applied at the rate of from 2 to 3 ounces per bushel, depending upon the amount of smut present. Smut mixing machines are now on the market for applying dust rapidly to large quantities of grain. Put the grain and copper carbonate dust into the mixing machine and rotate for 2 or 3 minutes or until every grain is thoroughly covered with dust. It is advisable to wear a dust mask or wet handkerchief over the mouth and nose while treating the grain. If a smut treating machine is not available, a home-made dust mixing machine may be made from a barrel churn or ordinary barrel, or some types of cement mixers may be used for treating the grain.

The Advantages of Treating Wheat and Hulless Oats with Copper Carbonate Dust

(1) It does not injure germination.
(2) Seed can be treated when convenient and stored without injury.
(3) Dusted seed can be sown at any time in dry or moist soil.

Disadvantages

(1) Treated seed cannot be used for milling purposes.
(2) Treated seed must be kept dry and should not be allowed to stand in the seed drill.
(3) Any dust that collects in the seed drill should be cleaned out, as it may become caked and injure the drill.

N.B.—If the drill has not been used for a few hours, it is advisable to rock the wheels before starting to loosen the grains and gearings.

Simple Home-made Dusting Machine

The following are the directions for making a very simple home-made dusting machine from a barrel and materials available on any farm.

The materials necessary are:—(1) A strong barrel with one head; (2) 4 short pieces of 2 x 2 pinewood; (3) 4 boards 6 inches wide by 3 feet long; (4) an old canvas; (5) a piece of rope or strap about 8 feet long; (6) 4 small wood blocks, 2 x 2 x 2, and a few nails.

Either an oil barrel or a lime-sulphur barrel or even a strong salt barrel can be used for making this machine. Remove one head of the barrel and clean it thoroughly. Next cut out a piece of 2″ x 2″ scantling of such length that it will just fit across the barrel 6″ from the bottom and nail in place. Then cut a second piece to fit just above this and fasten it at right angles to the first piece. Then cut two similar pieces to fit the other end of the barrel about 6″ from the top. Next take the four 6″ boards and cut one side to fit the curve of the barrel. These boards, after they are cut, should be firmly nailed to the cross pieces. Nail the four small blocks to the outside of the barrel about 2″ from the top. The machine now has the appearance of figure 15.

Directions for Using the Machine

Pour a bushel of the grain into the barrel and then add the correct amount of dust. Add a second bushel, and add more dust (Figure 16). Place a piece of canvas over the open end of the barrel and fasten it in place with a piece of rope or strap. Be sure to see that the rope is fastened just below the blocks on the outside of the barrel. Tip the barrel over on its side and roll it for 10 or 12 feet and then roll it back again. Repeat 2 or 3 times (Figure 17). Remove the canvas and empty the grain on the barn floor, so that it may be shovelled into bags (Figure 18).

With this simple machine, 60 bushels of grain may be treated in an hour. The dust will be thoroughly mixed with the grain. Furthermore, the dusted grain requires little handling and very little dust escapes, so that a gas mask or wet handkerchief over the mouth is not needed when copper carbonate dust is being used. By this method the dust is so thoroughly mixed with the grain that little inconvenience is experienced in sowing. This is especially true with hulless oats.

Copper Carbonate

This is a fine greenish powder. Brands containing 20 per cent. copper have been found as effective as those containing more copper. Copper carbonate

FIG. 15.—Home-made seed duster ready for use.

FIG. 16.—Putting grain and dust in the seed duster.

FIG. 17.—Mixing the grain and dust by rolling the barrel.

FIG. 18.—Emptying the barrel.

dust can be purchased from the local hardware stores or from any of the larger firms dealing in insecticides and fungicides. Copper carbonate dust is the safest and most effective seed disinfectant for the prevention of Bunt or Stinking Smut of Wheat and smut in hulless oats.

Formalin

Formalin is a clear liquid disinfectant. It is a 40 per cent. solution of Formaldehyde gas in water. It is sold under the names of Formalin and Formaldehyde. It can be purchased in drug stores and seed stores by the pound (16 ounces) or by the pint (20 ounces). It is important that the purchaser, whatever name he buys it under, secures a solution of full strength, at least not less than 38 per cent. It should be kept in a well-corked container away from frost. Formalin when diluted with water is not a dangerous poison, but a weak solution will make the eyes smart and a strong solution will harden the skin temporarily. Formalin is the safest and most efficient disinfectant for the prevention of oat smuts and Covered Smut of Barley, and it is at the same time comparatively cheap. Formalin will not prevent Loose Smut of Wheat or Loose Smut of Barley.

Hot Water Treatment for the Prevention of Loose Smut of Wheat and Loose Smut of Barley

It also prevents other smuts to which these grains are subject.

(*a*) *Preliminary Treatment (soaking)*

**Materials needed :*

1. One reliable thermometer; the ordinary bath-tub or room thermometer is very undesirable for this purpose, but a good dairy thermometer will serve the purpose well.
2. One large wooden barrel or any kind of metal tank or large vat.
3. A number of good strong grain bags which will allow the water to pass through rapidly.
4. Some kind of stove, boiler or fireplace to heat the water.

Procedure.—1. Heat water in the boiler to almost boiling. Pour into large barrel or tank (before proceeding further, refill the boiler with water) and add slowly, with vigorous stirring, cold water until the temperature is exactly 86 degrees F. Unless the water is well stirred the correct temperature cannot be taken. Read the temperature without removing the thermometer from the water. The mercury bulb should always remain submerged when taking the reading.

2. Fill grain bags three-quarters full with the grain to be treated and tie them up loosely. Immerse into barrel with water at 86 degrees F. Move bag several times up and down, which will force out the air quickly. Take care the water covers the grain at least several inches. Allow the grain to remain in this water four hours.

Note.—The temperature of the water will become lower when the grain is introduced. Should it cool down too quickly—i.e., sink below 68 degrees F.—allow five hours for soaking.

Treat the grain, if possible, in a heated room to prevent the rapid sinking of the temperature. By placing the barrel or tank in a large wooden box, tightly packed with wood shavings, hay or straw all around, and covering it with a lid, the temperature remains fairly constant for four hours, once the grain has assumed the temperature of the water. One ordinary barrel will treat about one bushel of grain or a little more. Use two or three barrels or one of larger size if more grain is to be treated. The larger the barrel and the greater the volume of water, the more easily will the temperature be kept constant.

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*Gussow H. T. and Conners I. L. Dom. Canada Dept. Agr. Bul. 81, n. s. 1927.

(b) Main Treatment with Hot Water

Additional requirements—Two large barrels or vats, each capable of holding from two to three bags of grain. A water can with a sprinkler attached.

Procedure.—Into the first barrel pour a quantity of nearly boiling water and add cold water slowly until the temperature is accurately 112 degrees F. (Fill up the boiler immediately, as more water will be required in a short while.) Then take out the grain from the "soaking" barrel and place in this one. Move several times up and down and allow to remain for 15 or 20 minutes.

Meanwhile prepare the other barrel; pour in hot water as near boiling as possible, add cold water slowly, with stirring, until the temperature is exactly 129 degrees F. Then take the bags out of the second barrel (the one with the water at 112 degrees F.) and place in the barrel with water at 129 degrees F. This will cause the temperature to sink to some extent; should it sink below 122 degrees F., fill the sprinkling can with hot water and sprinkle into the barrel, but under no circumstances upon the grain or the bags containing it. When, however, the bags are well covered with water, at least four or five inches, the hot water may be safely added. To mix it with the whole contents lift the bags up and down, or move them around the barrel. The grain must remain for exactly ten minutes in this last barrel, during which time the water should be maintained evenly at a temperature from 124 degrees F.—127 degrees F. It should never sink below 122 degrees F., nor be hotter than 129 degrees F. The former will be ineffectual in killing the smut, the latter will cause unnecessary damage to the grain.*

N.B.—To dry the wet grain rapidly after treatment place it so that it will be exposed to as strong a draft of air as possible.

This hot-water treatment can be made much easier if a steam boiler is available. If a feed cooker or steam threshing engine is at hand the water in the barrels used in the main treatment can be easily raised to the desired temperature by running a pipe or strong hose from the boiler to the barrels and allowing steam to pass into the water.

Also the correct temperature can be easily maintained during treatment by allowing a little steam to pass through the water while the grain is soaking. Care must be taken that the grain does not come in contact with the steam inlet and the water must be stirred to keep the temperature uniform through the barrels.

An easy method of keeping the water well stirred is to frequently raise and lower the sacks of grain in the treating barrels. In order that this may be easily done, the sacks should not contain more than a bushel of grain. Strong burlap sacks are very useful as water readily passes through the coarse mesh and as a bushel of grain will fill such sacks less than half full the hot water will readily penetrate to all portions of the grain.

PRECAUTIONS TO BE TAKEN TO INSURE SUCCESS OF METHODS RECOMMENDED TO PREVENT GRAIN SMUTS

(1) Learn to distinguish the different grain smuts, and be sure to use the method recommended for that particular one you wish to prevent.

(2) Great care must be taken to see that treated seed is not reinfected with smut spores. Sacks, bins, implements, etc., used in handling smutted grain must also be disinfected. The sacks should be dipped in or sprayed with a strong solution of formalin and the seed drill should be cleaned and disinfected with formalin. The floor on which the grain is spread out to dry should first be sprayed or mopped with a strong formalin solution.

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*Gussow H. T. and Conners I. L. Dom. Canada Dept. Agr. Bul. 81, n. s. 1927.

(3) In sprinkling with formalin solution, apply plenty to wet every grain in the pile, but not enough to drench the grain and make it soppy.

(4) Never leave treated grain covered longer than five or six hours.

(5) Sow the seed as soon after treatment with formalin solution as possible. If the damp grain is placed in bags, in the drill or in any close place for a few hours there is a danger of the vitality of the seed becoming weakened. If wet weather prevents seeding immediately after treatment, then take precautions to see that the grain is thoroughly dry before it is bagged.

(6) If seed wheat to be treated contains bunted grains (smut balls) they should be removed before treating the grain. This is especially important when formalin is used. This can be done with a good fanning mill.

(7) On no account allow treated grain to sprout or mould or to be frozen when swollen after sprinkling with formalin.

Patent Seed Disinfectants

Many patent seed disinfectants are now on the market. Some of them are very effective, but many of them are deadly poisons and most of them are rather costly. Our experiments show that none of them prevent smut better than formalin or copper carbonate dust used as recommended in this bulletin.

Cheap Insurance

In conclusion, it may be said that seed treatment to prevent grain smuts is cheap insurance that no farmer can afford to dispense with. Take no chances; treat your seed grain every year as directed in this bulletin and then every season your grain will be free from objectionable smut.